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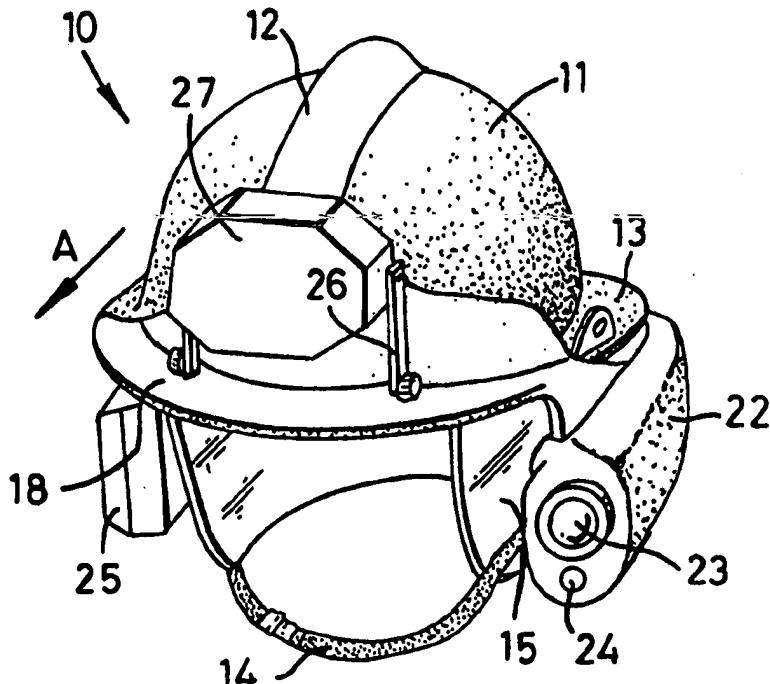
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(71) Applicant (for all designated States except US): I.S.G. THERMAL SYSTEMS LIMITED [GB/GB]; Integrated House, Repton Court, Repton Close, Basildon, Essex SS13 1LN (GB).		Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>	
(72) Inventors; and (75) Inventors/Applicants (for US only): PRESCOTT, John, Albert [GB/GB]; Thomcroft, 52 High Road, Layer-de-la-Haye, Colchester, Essex CO2 0DT (GB). NICHOLS, Andrew [GB/GB]; 6 Honeysuckle Path, Springfield, Chelmsford, Essex CM1 6XT (GB).			
(74) Agents: GILLAM, Francis, Cyril et al.; Sanderson & Co., 34 East Stockwell Street, Colchester, Essex CO1 1ST (GB).			

(54) Title: THERMAL IMAGING APPARATUS

(57) Abstract

Thermal imaging apparatus intended for mounting on a protective safety helmet (10), for example of a fire-fighter, has a registration section (18) adapted to locate against the forward brim (13) of a helmet. The registration section (18) forms of a part of a releasable mounting clamp (20), arranged to extend around the rear of the helmet, to secure the apparatus in position. To one side of the mounting clamp (20) is a thermal imaging camera assembly (22) and on the opposite side is a rechargeable power pack (25). A display device (27) is mounted on the registration section (18) by means of a pair of arms (26) so that the display device may be moved between an active position, where an image is within the wearer's field of view, and an inactive position, hinged up against the helmet. The apparatus is substantially balanced about a vertical central plane.



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THERMAL IMAGING APPARATUS

This invention relates to thermal imaging apparatus and in particular - but not exclusively - to such apparatus for use by fire-fighters. The invention further relates to thermal imaging apparatus in combination with a protective helmet for wearing, for example, by a fire-fighter.

A thermal imaging camera operates by detecting infrared radiation and, in conjunction with a display device, produces a visible image of the detected infrared radiation. Such a camera and display device has proved to be of great value in fire-fighting operations, since it enables an operator to see in total darkness, or where normal vision is partially or wholly obscured by smoke.

A known form of thermal imaging apparatus has a hand-held portable housing containing a power pack, a thermal imaging camera and a display device which may be viewed by a person carrying the apparatus. Though effective in operation, such apparatus is inconvenient in use; a fire-fighter when carrying the apparatus has only one hand available for other purposes, and if he requires both of his hands, he must put down the apparatus on a surface. Then, the fire-fighter may lose his view of an object, and may even lose the apparatus itself, in a heavily smoke-obscured environment.

In order to overcome the above problems, it has been proposed in GB 2241793B to provide a special form of head-protection helmet configured to include within the helmet a thermal imaging camera, power pack and display device. Such a solution is relatively expensive to implement, in that the helmet must be arranged to conform with all relevant safety standards despite containing the required equipment. Moreover, the helmet is inevitably significantly larger than a conventional helmet and thus a fire-fighter is more likely to subject the helmet to unintentional knocks and bumps. In addition, it is generally too expensive to furnish the helmets of all fire-fighters within a force with such thermal imaging apparatus despite the enormous advantages that such apparatus can confer, in appropriate circumstances. At the very least, a force would have to provide one helmet of each size with the

equipment, but even so, for fire-fighters to change helmets whilst undertaking a fire-fighting operation is not particularly practical or convenient.

It is an aim of the present invention to address the problems mentioned above of the known equipment. Accordingly, the present invention provides 5 thermal imaging apparatus comprising: a mounting clamp adapted to be releasably connected to a protective helmet; a thermal imaging camera; a display device arranged to produce visible images from the camera output; and a battery power-pack; the camera, display device and power-pack being mounted on the clamp such that in use with the clamp connected to a helmet 10 the field of view of the camera is substantially in front of a wearer of the helmet, the display device produces images in the wearer's field of view, and the camera and power-pack are disposed generally on opposite sides of the helmet.

It will be appreciated that with the apparatus of the present invention, 15 the apparatus may be mounted on or demounted from a protective helmet such as a fire-fighter's helmet, at will. Thus, a fire-fighter entering a dark or smoke-obscured zone may have the apparatus quickly attached to his helmet greatly to enhance his ability to work in that zone, and on leaving that zone, the apparatus may readily be detached from his helmet and attached to that of 20 another fire-fighter. In this way, a fire-fighting force may invest considerably less in such equipment without losing operational capabilities, with consequent economic advantages.

The thermal imaging apparatus of this invention may be configured for 25 use with either of the two kinds of protective helmet commonly used by fire-fighting forces. Thus, the apparatus may be used with a protective helmet having a hard main head-protecting portion which extends over the top of the head of a wearer, the helmet having a substantially planar lower periphery and a brim which projects outwardly from that periphery. Alternatively, the apparatus may be used with a full helmet, the hard head-projecting portion of 30 which covers not only the upper region of the head but also extends over the ears and the back part of the head. In the former case, when the mounting clamp is secured to the helmet, the camera and power pack could be disposed

below the helmet brim, adjacent the respective ears of a user, or the clamp could be arranged to support these components above the brim. In the case of a full helmet, the camera and the power pack are preferably disposed in the region of the ear-protecting portions of the helmet, on opposed sides thereof.

- 5 In either case, the clamp may have a registration section adapted in use to engage both a forward-facing lower part of the head-protecting portion, and the helmet brim or periphery (as appropriate) of the helmet at said part. Such a registration section may serve firmly to secure the mounting clamp in position on the helmet, as well as facilitating the proper positioning of the
- 10 clamp, when mounting it on a helmet.

Preferably, the clamp has a securing band adapted to extend around the rear part of the helmet, from the two ends of the registration section. Such a band may be in two parts connected respectively to the two ends of the registration section and the free ends of the two parts being arranged for coupling together to connect the clamp to a helmet. Advantageously, the coupling for the two free ends should be adjustable, to allow for variations in helmet size.

- 15 Most preferably, when in use the camera should be disposed on one side of a helmet so as to face generally forwardly, the power pack being disposed on the other side of the helmet opposed to the camera, and the display device being carried by the clamp between the camera and the power pack. Such an arrangement may have the advantage that the camera, power pack and display device are substantially balanced about a vertical mid-plane with respect to a helmet to which the clamp is connected, so that the helmet will tend to sit in the same position on a wearer's head, whether or not the thermal imaging apparatus of this invention is connected to the helmet.
- 20
- 25

Conveniently, the display device is mounted on the clamp by means permitting movement of the device from a raised position above the lower edge of the helmet in the region of the eyes of the wearer and a lowered position where the device produces images in the field of view of the wearer of a helmet. For example, the display device may be carried on a pair of arms

pivoted to a section of the clamp, to permit raising and lowering of the device by swinging movement of those arms.

The display device could be in the form of a screen which a wearer of a helmet to which the clamp is mounted may direct his vision. Alternatively, the 5 display device may project an image into the eyes of a wearer of the helmet, in a manner known in the art. Such a display device may be in the form of binocular viewing goggles, an image being projected into both eyes when the display device is in the appropriate position.

The apparatus of this invention may include a temperature sensor, for 10 example looking forwardly and with either a broad or narrow acceptance angle, and in the latter case to be focused upon a cross-wire sight in the display device. Such a sensor conveniently drives a digital temperature display, in the main display device.

The camera module may be demounted from its housing and be 15 coupled either with an umbilical cord or with a radio signal to the display device, so that an operator may increase his field of view, by hand-holding the camera. For instance, in this way a fire-fighter may look round a doorway into a room before exposing his entire body in the doorway. Moreover, the power pack and display device may also be demountable from the clamp and be 20 arranged for assembly with the camera module into a complete, self-contained thermal imaging camera device for simple hand-held use.

There may be advantages in providing the apparatus with a radio transmitter, connected to the output of the thermal imaging camera and to the output of a video camera, if provided. In this way, a signal corresponding to 25 the field of view of the (or each) camera may be sent back to a control point, so that (for example) a co-ordinator may assist in a fire-fighting or rescue operation. Such a co-ordinator may have a two-way audio radio link with each fire-fighter, to assist in the direction of the personnel.

This invention extends to thermal imaging apparatus of this invention as 30 described above in combination with a protective helmet to which the clamp is connected.

By way of example only, three specific embodiments of thermal imaging apparatus constructed and arranged in accordance with the present invention will now be described in detail, reference being made to the accompanying drawings, in which:-

5 Figure 1 is a perspective view of the first embodiment, intended for use with a brim style of protective helmet;

Figure 2 is a perspective view of such a helmet;

Figure 3 shows the helmet of Figure 2 with the apparatus of Figure 1 mounted thereon;

10 Figures 4 and 4A show a second embodiment of apparatus of this invention for use with a full style of helmet, respectively with a clamp in closed and open positions;

Figures 5 and 6 show a full style of helmet and the apparatus of Figure 4 mounted on the helmet, respectively; and

15 Figures 7 and 8 show a third embodiment, also intended for use with a brim style of helmet.

In Figure 1, there is shown the first embodiment of thermal imaging apparatus intended for use with a standard "brim" style of protective helmet 10 shown in Figure 2. This helmet has a principal head protecting portion 11 with 20 a fore-and-aft reinforcing rib 12 and a peripheral brim 13, projecting outwardly from the lower edge of portion 11. The brim 13 lies substantially in a single plane and extends immediately above the ears of a wearer. The helmet is provided with a fabric protection sheet 15 which extends over the ears of a wearer and round the back of his head, and straps 14 hold the helmet in place 25 on the head of a wearer.

The apparatus itself comprises a mounting clamp constructed from a registration section 18 configured to fit over the front portion of brim 13 of a helmet, with a flange 19 then lying against the forward-facing part of the lower front of the helmet 11, and a two-part securing band 20 which is attached to 30 the two ends of the registration section 18. The free ends of the two parts of the band 20 are provided with an adjustable coupling device 21 of a kind known in the art, and permitting the free ends to be connected together with

tension in the band. As shown, the securing band may be of a fabric which may be faced with a friction material so as to minimise slippage between the band and a helmet to which the apparatus is connected. Further to assist tightening of the band, it may be made from an elastic material, or may include 5 an elastic section, though any such elastic material and the fabric from which the band is made should be of a heat-resistant material, so as to minimise deterioration in use, in hostile environments. Alternatively, the band may be made of a flexible or even substantially rigid material, profiled to have the required shape to fit a given helmet.

10 Connected to the underside of one end of the registration section is a housing 22 for a miniature thermal imaging camera, arranged with its lens 23 facing forwardly so as to have substantially the same field of view as that of a fire-fighter wearing the helmet 11. The housing may also contain a video camera having a lens 24. Connected to the underside of the other end of the 15 registration lip is a rechargeable battery power pack 25. Thus, the camera and the power pack are arranged adjacent the respective ears of a wearer, and are substantially balanced about the vertical mid plane of the helmet 11, when the apparatus is connected thereto.

A pair of arms 26 are pivoted to the central portion of the registration 20 section 18 and support at their other ends a binocular display device 27. This device receives appropriate signals from the thermal imaging camera mounted within the housing 23 and projects a suitable image into the eyes of a wearer of the helmet to which the apparatus is connected, when the display device is in its lowered position as shown in broken lines in Figure 1. When the 25 operator no longer wishes to receive such images, he may simply raise the display device 27 so as to be above the brim 13 of the helmet, and in the event that he is unlikely to want to view the images for some time, he may turn off the apparatus using a switch (not shown) provided for that purpose on the power pack 25.

30 Figure 3 shows the apparatus mounted on the helmet of Figure 2, with the registration section locating on the front part of the brim 13. As can be seen, the band 20 extends from the two rear ends of the registration section

from locations below the brim, over the rear part of the brim with the coupling 21 at the back of the helmet. The band thus clamps the apparatus securely in position. To remove the apparatus, for example to permit it to be attached to the helmet of another fire-fighter, all that is necessary is for the coupling 21 to
5 be released, and then the entire apparatus can be pulled forward away from the helmet, in the direction of arrow A shown in Figure 3. The apparatus may then be mounted on another helmet simply by appropriately positioning the registration section 18 over the brim of that other helmet, pushing the apparatus home and then securing the coupling 21 behind the helmet.

10 Figures 4 and 4A show a second embodiment of apparatus intended for use with a full style of helmet, as shown in Figure 5. This helmet 30 has a rigid main part which extends not only over the top of a wearer's head, but also down over the ears and around the back of the head. The helmet has a single chin-strap 31, to hold the helmet in position.

15 The apparatus shown in Figure 4 is functionally similar to that of Figure 1 and like parts are given like reference numbers; these parts will not be described again here. The mounting clamp has a substantially rigid member 32 provided with a registration lip 33 configured to fit over the peak 34 of the helmet, the member 32 being profiled to fit around the front portion of the
20 helmet. The camera assembly is in two parts, there being a remote detecting lens head 35 connected electrically to an electronic unit 36, both parts being mounted on the member 32 so as to lie outside the rigid part of the helmet, but in substantially the same position relative to the head of a wearer as in the case of the first embodiment. The lens head 35 may be pivoted with respect
25 to member 32, to a selected click-stop position. When in use, a wearer may perform this pivoting action with a gloved hand, to alter the wearer's field of view - for example when the wearer is having to crawl with his head lowered.

30 The power pack 25 is mounted on the opposite side of the member 32 to the camera assembly so that the equipment is substantially balanced about a vertical central plane. As with the camera assembly, the power pack lies outside the rigid part of the helmet, but in substantially the same position with respect to the head of a wearer as in the case of the first embodiment.

The display device is coupled to the registration section 33 or to member 32 in the same manner as has been described above for the first embodiment and may be moved between active and raised positions, by swinging movement of the arms 26.

5 The apparatus of Figure 4 is secured to a helmet 30 by means of two clips 38 and 39 attached to the lower front sides of the member 32 and each able to engage round the corresponding edges of the helmet, as shown in Figure 6. No releasable coupling is provided on the band 20; rather, the two parts of the band are pivoted together at 40, and the clip 38 is movable
10 between released and clamping positions. When clip 38 is released (Figure 4A), the side arm of the member 32 may be hinged away from the helmet whereafter the apparatus may be lifted off the helmet.

15 Figures 7 and 8 show an alternative embodiment, suitable for use with a brim style of helmet. Again, like parts with those of the previous embodiments are given like reference numbers.

20 The power supply unit and electronics associated with the camera imaging system are incorporated into a sealed curved housing 42, adapted to fit the helmet contour when located above the rear brim of the helmet. This housing serves as part of the mounting clamp for the apparatus and has a releasable clip 43 engageable with the rear brim of the helmet securely to hold
25 the apparatus in position. The imager detecting lens head 35 is pivotally mounted to the housing 42, as with the previous embodiment to allow adjustment of the field of view.

30 The ends of the housing 42 are connected to the ends of the registration section 18 by means of a pair of pivoted arms 44, catches 45 being provided on the housing to lock the arms to the housing, in a pre-set disposition. The apparatus is secured to a helmet by holding the housing 42 vertically above the helmet with the registration section 18 across the front of the helmet. The apparatus is moved rearwardly to locate the registration section on the front lip of the helmet. The housing 42 is then swung over the helmet and down on to the upper surface of the brim, at the back of the helmet, clip 43 engaging under the brim. The apparatus is tightened into

position by catches 45, securing the arms 44. Removal is the reverse of this fitting procedure.

By appropriately positioning the power pack within the curved housing generally opposite to the imager detecting lens head 35 good weight
5 distribution and balance about the vertical central plane can be achieved.

It will be appreciated that with all three embodiments, the configuration of the mounting clamp may be altered to suit the design of a helmet with which the apparatus is intended to be used. Fire-fighters within a given force usually have the same design of helmet, and thus apparatus configured to be
10 mountable on one particular helmet should fit all of the helmets used in that force, irrespective of the helmet size, by adjustment of the mounting clamp. In this way, there is no need for all fire-fighters to be provided with the thermal imaging apparatus; it is sufficient for the force to have as many sets of the apparatus as might be required at any one time, so leading to significant cost
15 savings.

Though not shown in the drawings any of the helmets described above may be fitted with a smoke hood or with a visor, as known with conventional helmets. Such a hood or visor may be used in conjunction with the apparatus of this invention, without interfering with the functionality thereof.

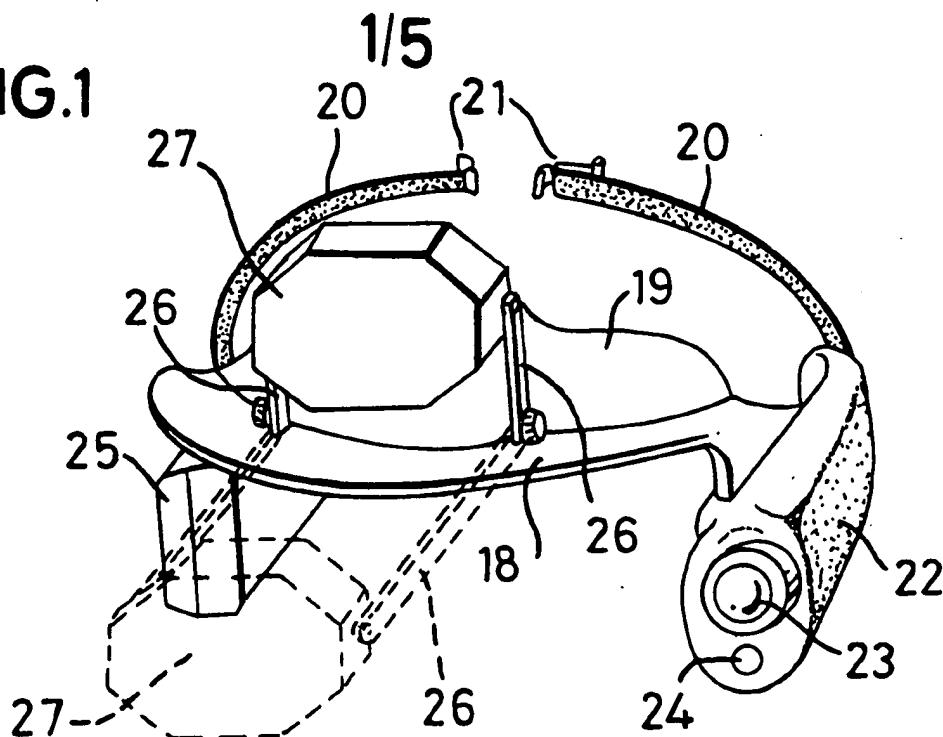
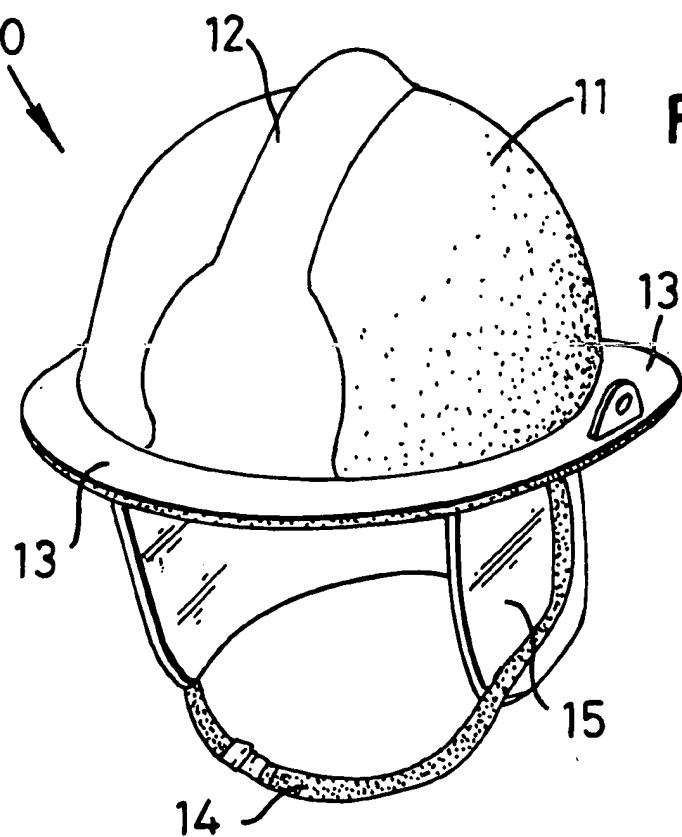
CLAIMS

1. Thermal imaging apparatus comprising: a mounting clamp adapted to be releasably connected to a protective helmet; a thermal imaging camera; a display device arranged to produce visible images from the camera output; and a battery power-pack; the camera, display device and power-pack being mounted on the clamp such that in use with the clamp connected to a helmet the field of view of the camera is substantially in front of a wearer of the helmet, the display device produces images in the wearer's field of view, and the camera and power-pack are disposed generally on opposite sides of the helmet.
2. Thermal imaging apparatus as claimed in claim 1 and for use with a protective helmet having a hard main head-protecting portion, wherein the mounting clamp is adapted to embrace the main portion of the helmet, in the region of the lower periphery of said portion.
3. Thermal imaging apparatus as claimed in claim 2 and in which the helmet has a brim projecting outwardly from a substantially planar main portion lower periphery, wherein the camera and the power pack are disposed below the helmet brim when the clamp is connected to the helmet, with the clamp disposed above the brim.
4. Thermal imaging apparatus as claimed claim 3, wherein the clamp has a registration section adapted in use to lie against a part of the brim and against an adjacent part of the head-protecting portion.
5. Thermal imaging apparatus as claimed in claim 2 and in which the main portion of the helmet extends over the greater part of the head of a wearer, wherein the camera and the power pack are disposed in the region of the ear-protecting portions of the helmet.
6. Thermal imaging apparatus as claimed in any of claims 3 to 5, wherein the clamp has a registration section adapted in use to engage a forward-facing lower part of the head-protecting portion and the helmet periphery of the helmet at said lower part.

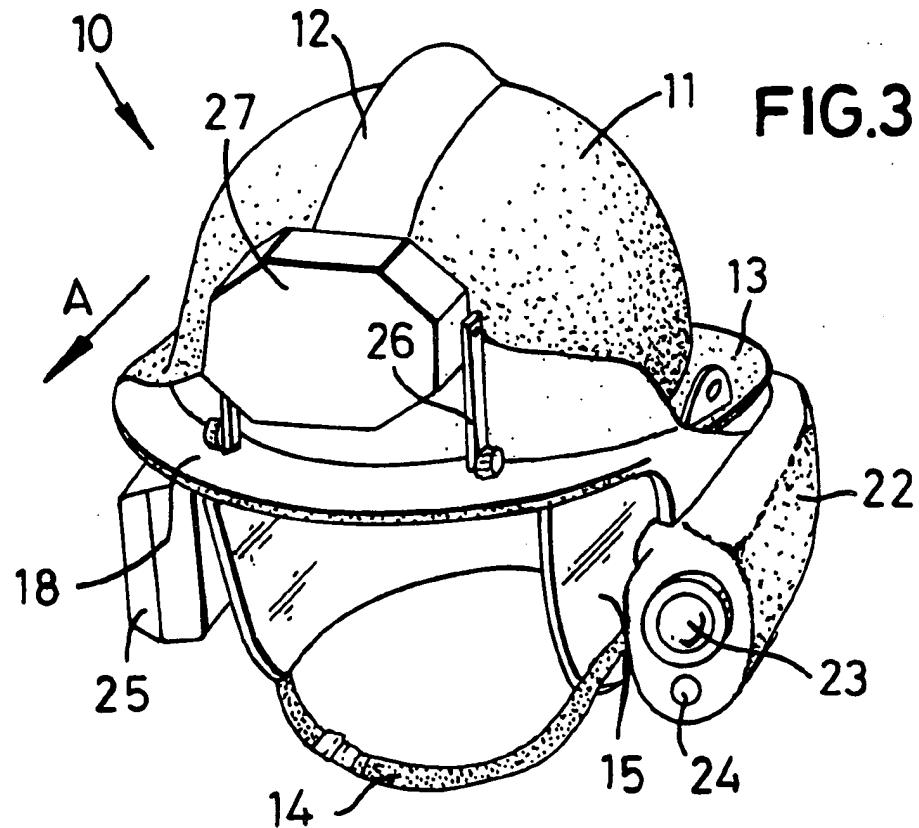
7. Thermal imaging apparatus as claimed in claim 4 or claim 6, wherein the clamp has a securing band adapted to extend around the helmet from the two ends of the registration section.
8. Thermal imaging apparatus as claimed in claim 7, wherein the band is in two parts connected respectively to the two ends of the registration section and the free ends of the two parts are arranged for coupling together, to connect the clamp to a helmet.
5
9. Thermal imaging apparatus as claimed in any of the preceding claims, wherein in use the camera is disposed on one side of a connected helmet and faces generally forwardly, the power pack is disposed on the other side of the helmet opposed to the camera, and the display device is carried by the clamp between the camera and the power pack.
10
10. Thermal imaging apparatus as claimed in claim 9, wherein the camera, power-pack and display device are substantially balanced about a vertical mid-plane of the mounting clamp.
15
11. Thermal imaging apparatus as claimed in claim 10, wherein the mounting clamp includes a curved housing adapted to extend around the rear portion of a helmet, at least the power pack being located in said housing.
12. Thermal imaging apparatus as claimed in any of the preceding claims, wherein the display device is mounted on the clamp by means permitting movement of the device from a raised position above the lower edge of the helmet and a lowered position where the device produces images in the field of view of a wearer of a helmet on which the apparatus is mounted.
20
13. Thermal imaging apparatus as claimed in claim 11, wherein the display device is carried on a pair of arms pivoted to a section of the clamp, to permit raising and lowering of the device.
25
14. Thermal imaging apparatus as claimed in any of the preceding claims, wherein the display device projects an image into at least one eye of a wearer of a helmet on which the apparatus is mounted.
- 30
15. Thermal imaging apparatus as claimed in any of the preceding claims, wherein the display device is in the form of a binocular viewing goggles.

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16. Thermal imaging apparatus as claimed in any of the preceding claims, wherein the thermal imaging camera has a separate lens head pivoted to the mounting clamp.
17. The combination of thermal imaging apparatus as claimed in any of the
5 preceding claims and a protective helmet to which the clamp is connected.

FIG.1**FIG.2**

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FIG.4

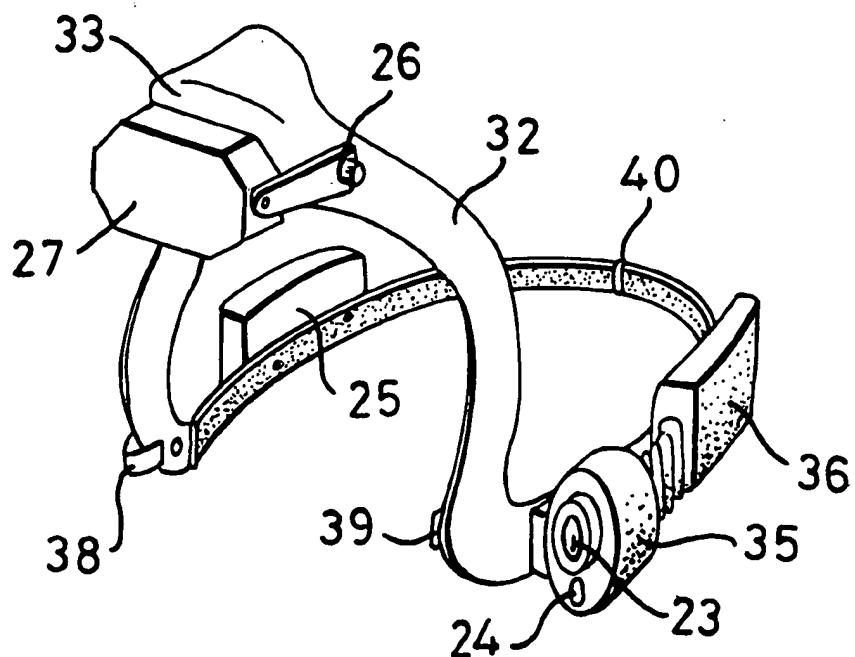
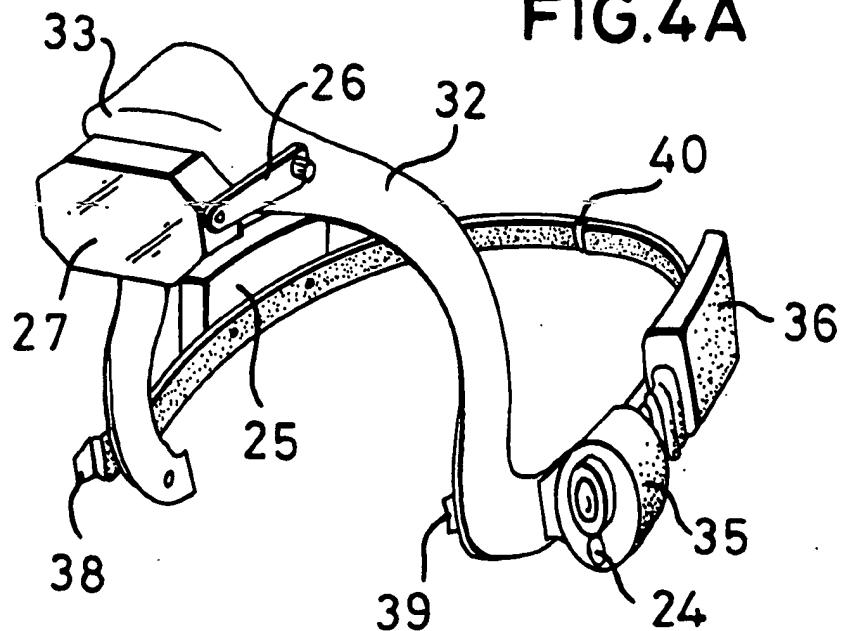


FIG.4A



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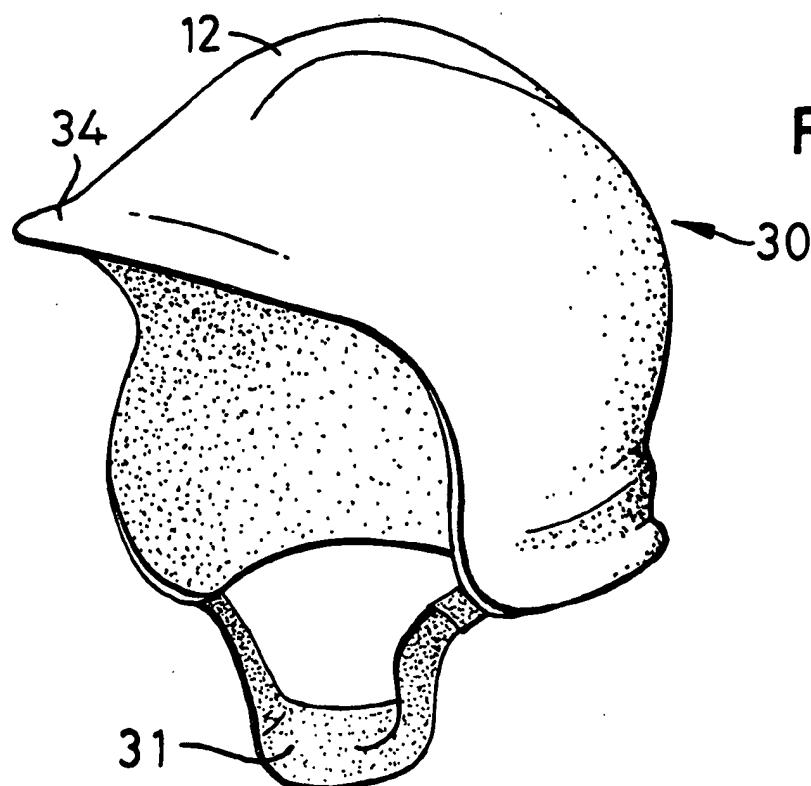


FIG. 5

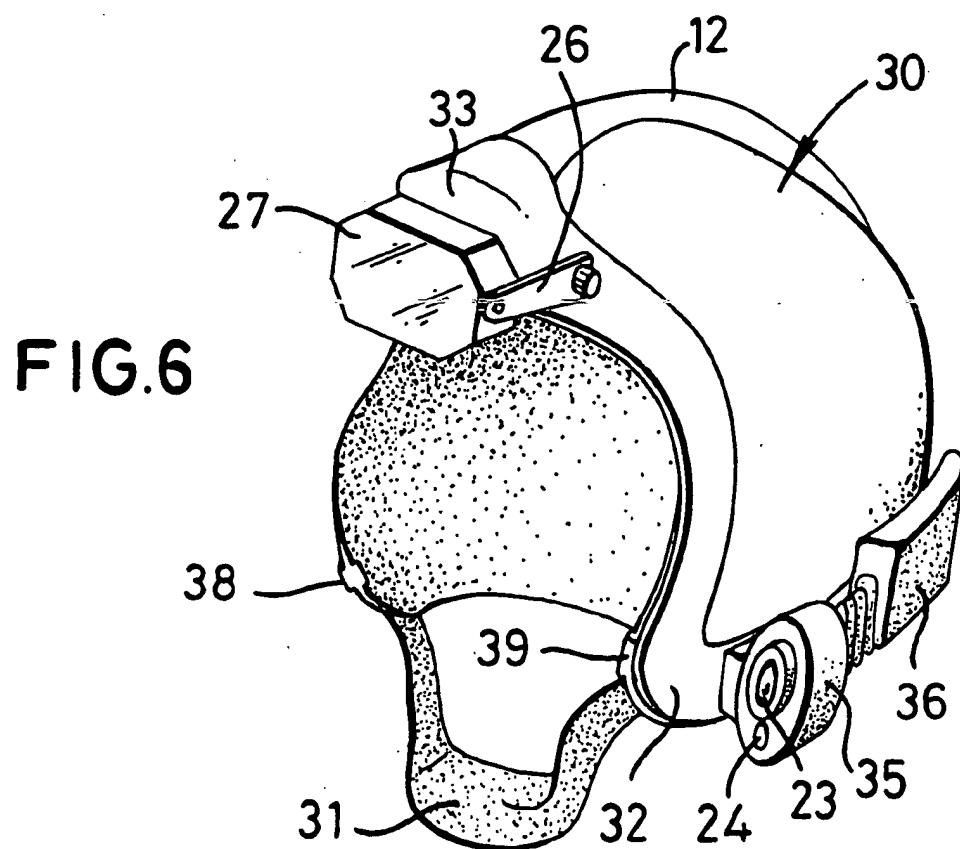


FIG. 6

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FIG.7

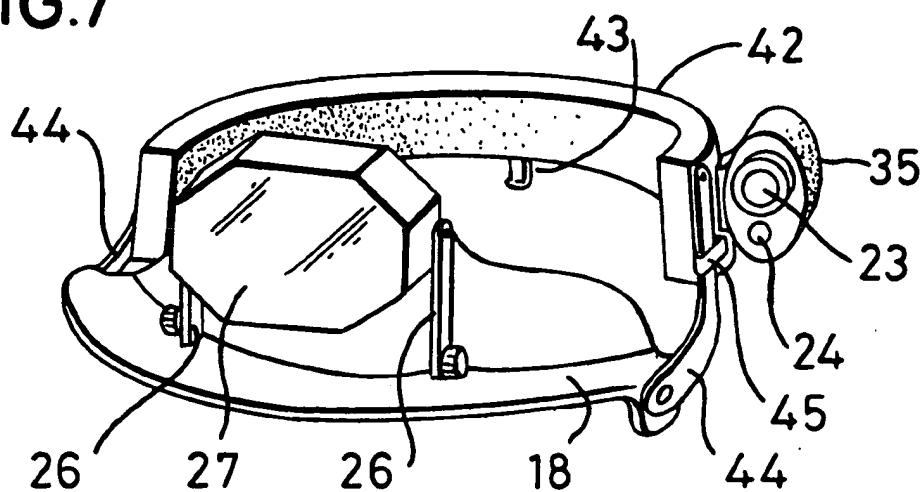
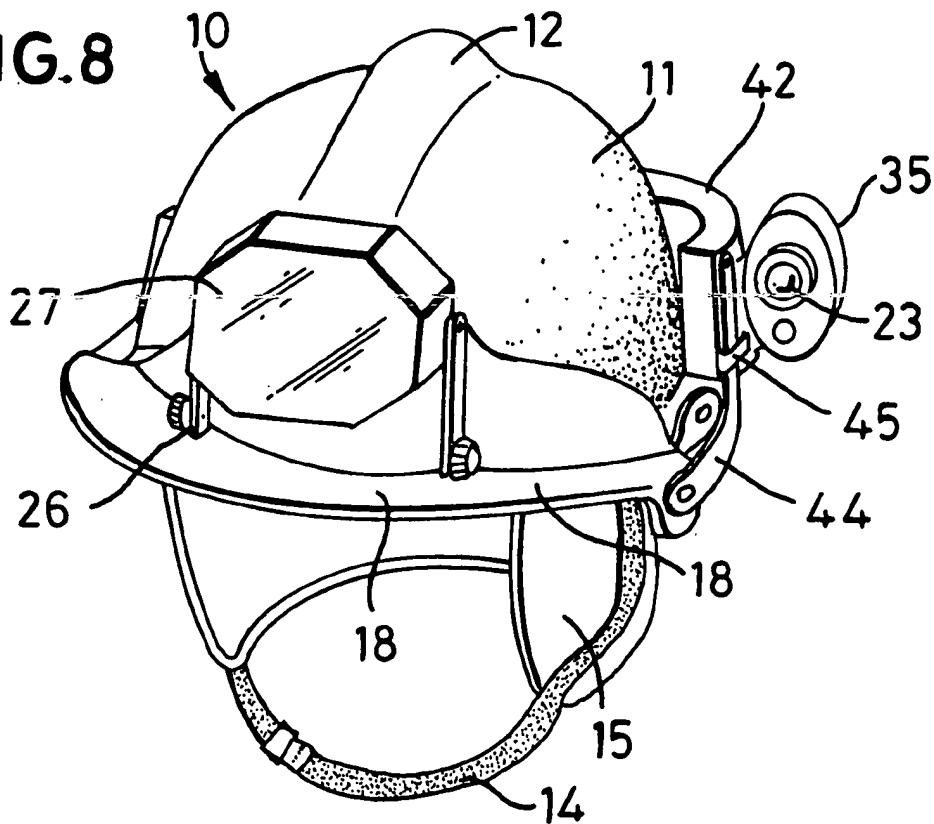


FIG.8



INTERNATIONAL SEARCH REPORT

Inten. Application No

PCT/GB 00/00267

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 7 G02B27/01 A42B3/04 A62B17/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

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 IPC 7 G02B A42B A62B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 95 31909 A (HELMET INTEGRATED SYST LTD ;BRIGGS ADRIAN (GB); DAMPNEY IAN TREVOR) 30 November 1995 (1995-11-30) whole document figures 1-4	1-11, 14, 17
Y	FR 2 732 121 A (EPREST ELECTRONIQUE PROFESSION) 27 September 1996 (1996-09-27) whole document figures 1-4	1-17
Y	EP 0 622 030 A (CAIRNS & BROTHER INC) 2 November 1994 (1994-11-02) column 3, line 28 -column 4, line 36; figures 1,2,8,9A-D,14,15 column 8, line 32 -column 10, line 10	1-10, 12-17

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

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Inte	onal Application No
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